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ANALYZING THE CITRUS ORCHARD BY MEANS OF SIMPLE TREE RECORDS

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CONTENTS

INTRODUCTION

The factors governing success in the raising of citrus fruits in California may be divided for convenience into three general classes: those determined by the grower in the cultural practices used; those which have to do with the inherent character of the trees themselves; and those related to the orchard environment. For best results, the maintenance of an optimum combination of these groups of factors is required.

Thus far the factors receiving the most attention, both on the part of the grower and the investigator, have been the cultural practices used, and it is gratifying to note that as a result in the past decade there has been a marked increase in efficiency on the part of citrus growers in the application of such practices as irrigation, fertilization, pruning, and pest and disease control.

The inherent qualities of the trees have also received considerable attention, especially during recent years, with the result that much more care is now given to the selection of stocks and bud-wood than was formerly the case.

Beyond the general questions of soil and climatic limitations, however, comparatively little attention has been given to the important matter of the orchard environment and especially its relation to cultural practices. Unquestionably much, if not most, of the wide variation in the yields of citrus trees is due to differences in environmental conditions as related to cultural practices and may therefore be overcome, at least partially, through an appreciation of this fact on the part of the grower. It is certain that closer attention to this class of factors may be expected to materially increase the efficiency of the average citrus orchard.

ORCHARD ANALYSIS

As a means of visualizing the relations of these three groups of factors, indicating the means of modifying them to advantage, and at the same time determining the relative efficiency of the orchard, a method of analysis is herein suggested which has been developed from an experience of five years of such work. It is believed that its use will do much in indicating the nature of the causes of failure to secure satisfactory yields, and also ways and means for increasing the production of the average orchard.

ESTABLISHING TREE IDENTITIES

The individual tree is the ultimate unit of the citrus orchard, a fact not sufficiently appreciated by the average grower, who is accustomed to thinking in terms of acres. The change in attitude from the acre, as the unit of production, to the tree is necessary before the type of analysis herein suggested can be undertaken. The first step in such an analysis, therefore, is the establishing of an identity for each tree in the orchard. A natural and logical method is that wherein each tree is given a set of numbers, which not only serve to establish a permanent identity but also to designate the location.

The system most commonly used consists of two numbers, the upper giving the row number, and the lower the tree number (fig. 1). Where a large acreage is involved, divided into several blocks, it is necessary to have the block number in addition to the row number and the tree number. For the average planting, however, the block

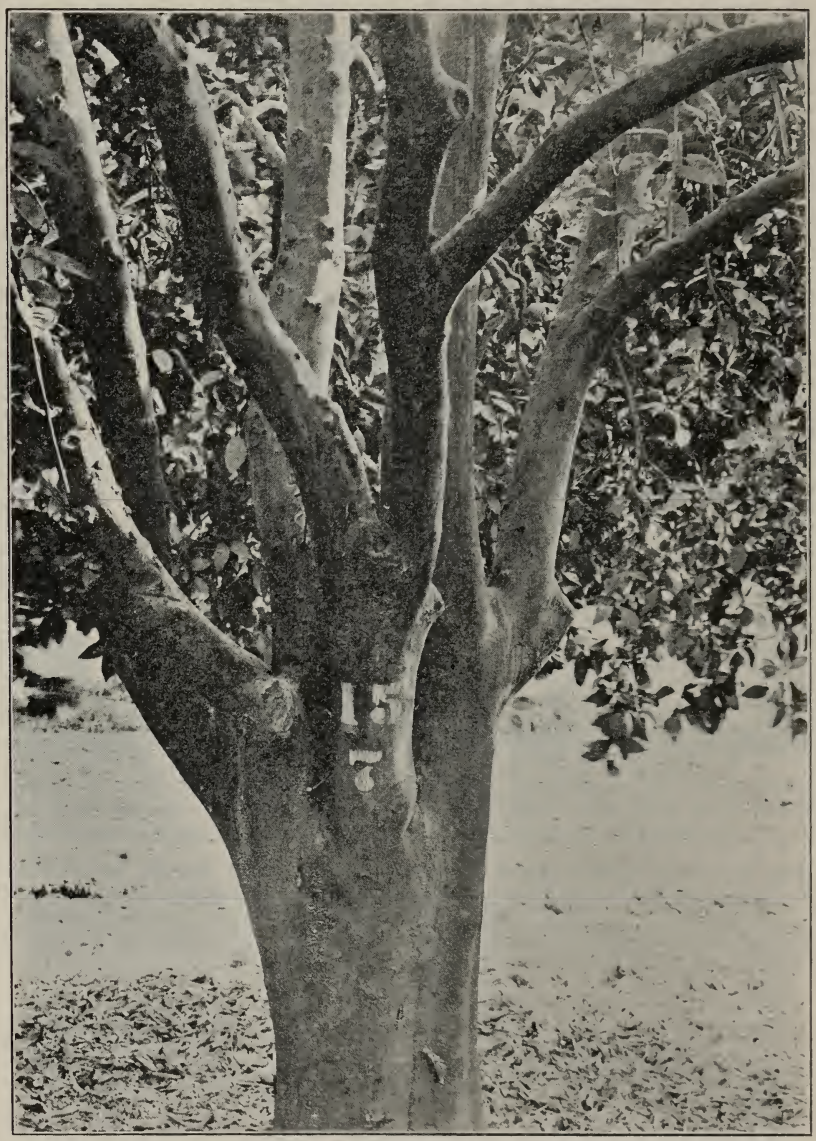


Fig. 1.—Showing method of painting numbers on tree trunks. The upper number gives the row, the lower number the tree. Numbering may be done either by use of stencils or free hand.

number is unnecessary. For convenience, the numbers should always be placed on the same side of the tree and at about the same height from the ground. A logical and recommended system of numbering is that in which the row numbers run in the direction of flow of the water in the standpipe lines, and the tree numbers in the direction of

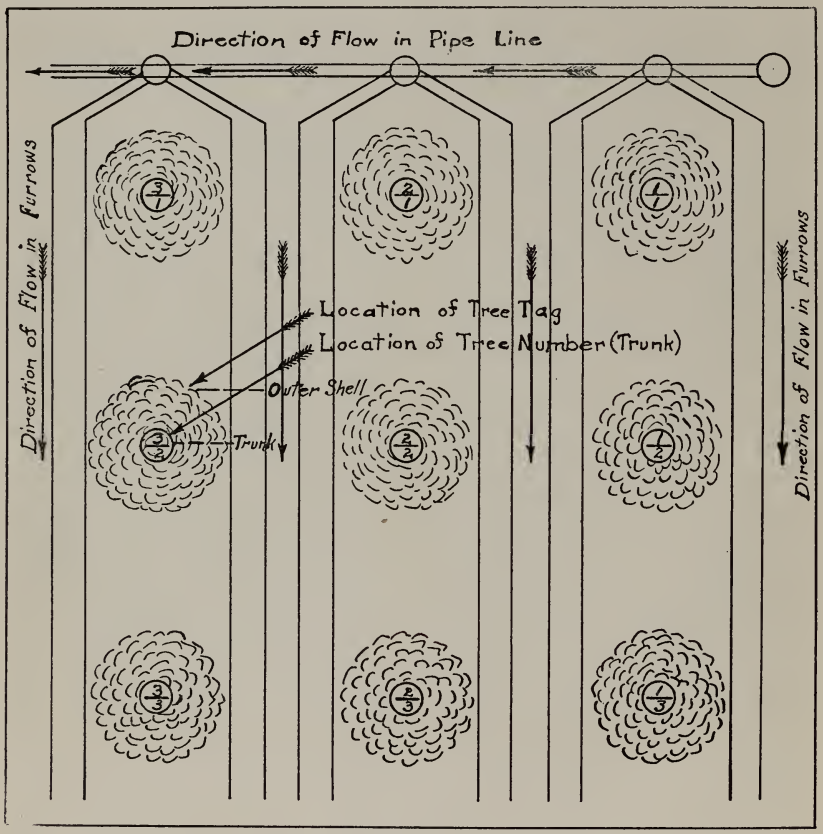


Fig. 2.—Diagramatic sketch showing recommended system of numbering rows and trees as related to irrigation. Row numbers follow the direction of water flow in the pipe lines; tree numbers follow the direction of flow of water in the irrigation furrows. Numbers are always placed facing the direction of the flow of water in the irrigation furrows.

flow of the water in the furrows. The numbers should be placed on the side of the tree facing the direction from which the irrigation water flows. (fig. 2.)

The most commonly used method of affixing the numbers is painting them directly on the trunk or on a main branch near the crotch, in figures from two to three inches in height, using a thick mixture

of white lead and linseed oil. (fig. 1.) If the bark is thoroughly cleaned before the painting is done, and good materials used, the numbers will last for many years. The numbers are sometimes painted on small boards and nailed to the trunks of the trees. For young trees, stakes with the numbers painted on them are sometimes used.

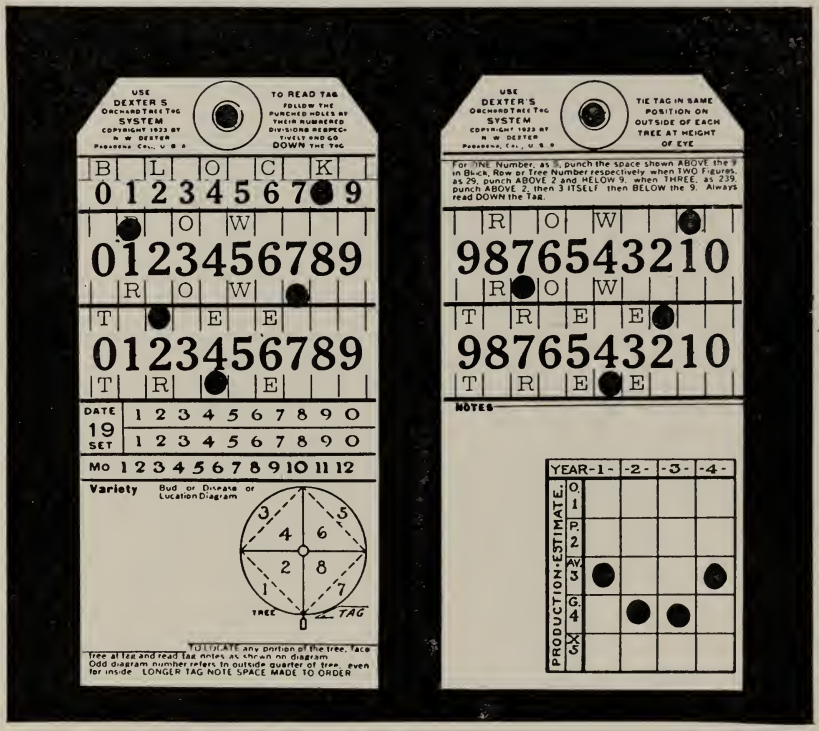


Fig. 3.—Tree tag combining identity and location record with estimate production record. Read down the tag for block, row and tree numbers. Numbers are the same on reverse side. Block *8*, Row *17*, Tree *24*.

Metal tags of various kinds have been used to a limited extent and also water proofed paper tags, the latter usually attached to the outer shell of foliage at a height of five to six feet. The paper tags seem to have considerable merit, especially those combining tree identity with production record, which will be referred to later. (fig. 3.)

The cost of numbering trees is small, ranging from two to four cents per tree. Painting the numbers on the trunks, either by means of stencils or free hand, while considerably slower than tagging the trees, appears to have fewer disadvantages than any other system yet devised.

KEEPING PRODUCTION RECORDS

The keeping of production records is of fundamental importance to the citrus grower, fully as much so as it is to the dairyman. No progressive dairyman today questions the value of the cow-testing association. The fact remains, however, that very few citrus growers keep individual tree production records. The keeping of tree production data is necessary to the carrying out of the method of orchard analysis described and recommended in this publication.

The Performance Record.—In determining the kind of records to be kept, however, the object for which the records are required is of primary importance. Citrus tree production records may be taken for two purposes, either to locate and test high producing trees to be used as sources of bud-wood for propagation, or to determine what trees are consistent low producers. In the case of the first object, it is of course obvious that as accurate records of quantity and quality of fruit as can be secured are necessary, even though the getting of such data involves considerable expense. Emphasis has therefore been placed on accuracy, to the degree of securing either the actual weight of fruit produced or approximately the same through a record of the number of boxes and half boxes picked. The tree performance record has therefore received considerable and well merited attention.

For purposes of determining low producing trees, however, and for the further objects of arranging the trees in classes according to relative production, such as is recommended in the method of analysis herein presented, such exactitude is unnecessary. In fact, the very trouble and expense of keeping actual tree performance records has been perhaps the principal factor in deterring citrus growers from undertaking orchard analyses.

The grower's problem is to determine what trees consistently produce only fair crops, and what trees are regular producers of good crops. The keeping of tree performance records, with the picking of the fruit from each tree separately is unnecessary as a means of securing this information.

Estimate Records.—The estimate production record is, judged from every angle, sufficiently accurate for the purposes mentioned, and is in addition so simple and practicable as to leave little excuse for failure to keep production records. Actual experience has shown that not to exceed two days' work a season will suffice to keep estimate production records for a ten-acre orchard.

A number of methods of estimate production record keeping have been used. Many growers, from long practice, have become expert

in estimating production in field boxes and with little effort can go through the orchard, taking two rows at a time, estimating the production per tree in boxes with remarkable accuracy. Picking foremen are usually expert in this practice and for a small additional sum to their wages are usually willing to make such estimates. This method is far simpler and less expensive than the tree performance record, and may be used successfully for orchard analysis purposes. It does not, however, differentiate between age of trees and size of trees, nor does it reflect seasonal variations. With this system old, large, but low producing trees and young, small but good producing trees are classed together.

A still better system is that of estimating the crop for each tree in terms of percentage of a theoretically perfect or hundred per cent crop. This system has been used by a few growers who have found it quite satisfactory. In using it the grower bears in mind what he considers a full or maximum crop for each tree, and the record taken down represents the percentage of this theoretically full crop which the tree is actually carrying. If the tree has half a crop the figure five is used to indicate that fact; if a full crop, ten, and so on. This method takes care of the factors of size and age relatively well but has too many divisions for great accuracy with the average grower. Moreover, it does not consider seasonal variation in yield due to uncontrollable weather conditions such as a heat wave during the period when the crop is "setting," low winter temperatures and other factors.

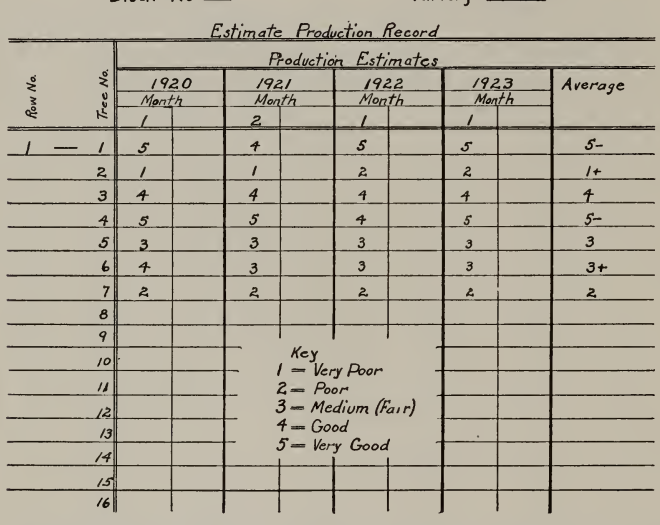
A much simpler system, and the one herein recommended, is the arbitrary fixing of three or five classes of trees according to relative production, *taking into consideration a normal full crop for the year.* Where only three classes are desired, the numerals 1, 2, and 3 may be used to designate poor, medium, and good production, respectively. If further division into five classes is desired as a means of more detailed analysis of environmental factors, the following are suggested:

1. Very poor.
2. Poor.
3. Medium (Fair).
4. Good.
5. Very good.

This system, it is believed, is more accurate than either of the two systems previously mentioned, and in addition is simpler and more readily used. Each tree is estimated on the basis of its size (which usually indicates age as well) and with regard to a normal

full crop for the year, considering general factors of a climatic character.

When to Make Production Estimates.—In the case of orange varieties, production estimate records are necessary only once a year. They should not be made until the fruit is practically mature and ordinarily should be taken just before picking begins. The accuracy of the operation, however, depends largely upon the judgment of the person making the estimates, and the work should therefore be done at a period when the fruit shows up well and before conditions causing the loss of a part of the crop by dropping of the fruit may


Block No 6 Variety Navels

Estimate Production Record

Row No.	Tree No.	Production Estimates 1920 Month 1	1921 Month 2	1922 Month 1	1923 Month 1	Average
1 —	1	5	4	5	5	5-
	2	1	1	2	2	1+
	3	4	4	4	4	4
	4	5	5	4	5	5-
	5	3	3	3	3	3
	6	4	3	3	3	3+
	7	2	2	2	2	2
	8					
	9					
	10					
	11					
	12					
	13					
	14					
	15					
	16					

Key
1 = Very Poor
2 = Poor
3 = Medium (Fair)
4 = Good
5 = Very Good

Fig. 4.—A suggested form for keeping estimate production records where the chart form is not desired. Estimates may be in boxes, percentage of full crop, or in terms of a comparison with a full crop for the year. The latter system is shown and is recommended.

occur. With Navel oranges, the period December to March is recommended. For Valencia oranges the estimates should be made early in the season, preferably between April 15 and June 1.

In the case of lemons it is necessary to record production estimates twice a year. The best periods for doing this vary somewhat in different districts but are in general November to January and April to June.

Estimate Production Record Forms.—Simple forms for the keeping of estimate production records are important. The data necessary are the row and tree number, and space for keeping production records for four or five years. Production records for four years it is believed are ample for purposes of orchard analysis. Simple forms

kept in permanent record books may be used. (fig. 4.) The production record may be combined with the tree identity tag, (fig. 3) or records may be kept on an orchard chart. The latter system has advantages, especially where the acreage is not large, in that, as will be brought out later, such a chart may be used both as production record and as distribution chart, thus eliminating the necessity of

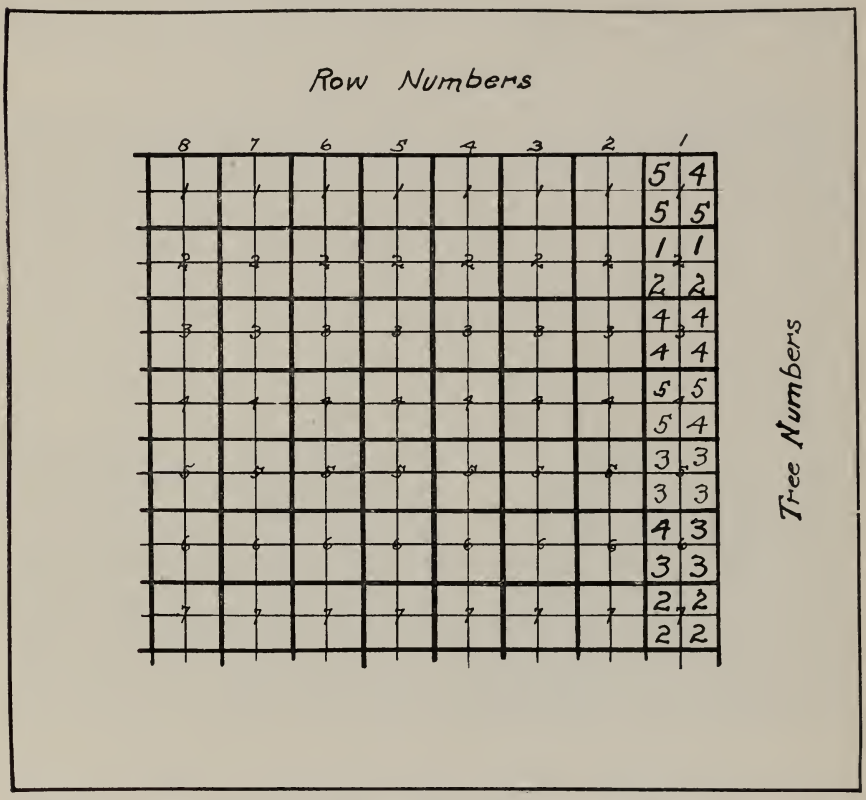


Fig. 5.—A chart form of production record which also serves as a distribution chart when the production estimates are shown in different colors. Each heavy square represents a tree. The smaller squares provide for four years' records. This system of keeping production records is recommended. Key: 1 = very poor; 2 = poor; 3 = medium (fair); 4 = good and 5 = very good.

transferring production data or preparing a separate distribution chart. The form of chart recommended is that shown in figure 5. Each tree is represented by a square which is divided into four parts, thus providing for four years' records. The method of division of the square suggested is recommended as furnishing a more satisfactory distribution chart when completed, than any method yet devised.

SEGREGATION INTO GROUPS ACCORDING TO PRODUCTION

On the basis of a single year's production records, the trees may be grouped in classes according to production, although it is probable that such groupings cannot be regarded as more than indicative until production records for three or four years are available. The latter period is recommended in the belief that four years of comparative production estimates is sufficient upon which to proceed with an analysis of the orchard.

When such records have been taken and averages for the period computed, the trees may be arranged in classes according to production. For all practical purposes only three classes are necessary, although the variation curve derived from segregating the trees into a larger number of classes is decidedly significant in indicating the relative efficiency of the orchard. The grower is primarily interested, however, in only three classes of trees: those failing to make a return equal to the amount expended in their care, usually referred to as "boarders"; those producing sufficient fruit to approximately meet production costs but not returning a profit, commonly called "self-supporters;" and those trees making a return in amount larger than their share of production costs, which may be designated as "profit-returners."

Orchard Efficiency.—Obviously, trees which have consistently produced very poor or poor crops (classes 1 and 2 in the five class estimate production record system) are not returning sufficient income to balance production costs. It is equally certain that the profits returned from the orchard are derived from those trees producing good or very good crops (classes 4 and 5). Trees producing fair crops (class 3) may then be regarded as on the average making returns approximately equal to costs, or in other words, self-supportingly only. On the basis of these classes the grower is in a position to determine quite accurately the relative efficiency of his orchard in terms of the percentages of trees which are carried at a loss, are merely self-supporting, and actually return a profit. The results of segregation into classes according to these recommendations as secured from three orchards analyzed are presented in table 1.

It will be noted that even in the case of an outstandingly profitable orchard, segregation of the trees into these classes shows that approximately one tree in three is either only self-supporting or is actually carried at a loss. In the average orchard it is believed that the percentage of such trees is nearer one-half.

TABLE 1

Percentage of Non-Profitable, Self-Supporting, and Profitable Trees in Three Different Citrus Orchards as Shown by Analysis

	Orchard 1*	Orchard 2	Orchard 3
Percentage of unprofitable trees	13.0	14.0	32.0
Percentage of self-supporting trees	19.0	32.5	42.0
Percentage of profitable trees	68.0	53.5	26.0
Total number of trees	5736	800	1525

Fig. 6.—This orchard has made net returns exceeding $500 per acre per year for the past four years. Notwithstanding this fact, analysis shows that only 68 per cent of the trees are returning a profit.

DISTRIBUTION IN THE ORCHARD ACCORDING TO PRODUCTION

Having ascertained the relative efficiency of the orchard as shown by segregating the trees into three main groups according to production, the practical consideration is to determine if possible the causes of the consistent variation in yield used as the basis for such segregation. Is it possible to bring the low producing and medium producing trees up to the average of the group returning profits? Does *consistent* low or medium production demonstrated over a period

*This orchard has produced net returns of over $500 per acre for a period of years. (fig. 6.)

of years mean *inherent* low or medium producing capacity? At this point in the analysis these and other questions of a similar character should occur to the thoughtful grower.

Consistent Performance vs. Inherent Capacity.—In the majority of cases where growers have reached this point in orchard analysis, the conclusion has been hastily arrived at that *consistent* low production at least, indicates *inherent low fruit bearing capacity.* In many cases trees of this class have either been removed or top-worked, frequently with the result that the new trees or top-worked trees have failed to do better than the original trees. The fact is that *consistent* low production does not necessarily mean low production from *inherent* causes. In the majority of cases low production is the product of environmental factors, which may be either wholly or partially remedied.

The Distribution Chart.—Much valuable information relative to the causes for *consistent* medium, and low production may be had from a study of the distribution of the trees in the orchard according to yield. This is most readily visualized by means of a distribution chart on which the three classes of trees as above referred to are shown in different colors. A study of the distribution chart furnishes invaluable information as to the causes and remedies for consistent yield variation.

In the majority of cases it will be found that the trees belonging to the three classes are arranged in groups, bands, zones, or areas, instead of being scattered here and there according to the law of chance. Such being the case, it is obvious that there must be one or more general factors affecting all the trees in a given group or area, responsible for and reflected in the production. Such factors are therefore outside the trees themselves and of necessity must be *environmental* in nature.

If, however, the trees are found distributed by classes without any apparent relation one to another, such as would occur according to the law of chance, the inference is reasonable that, unless impaired by pests or diseases, the causes for consistent differences in yield lie within the trees themselves and as such are *inherent.*

The making of a satisfactory distribution chart is therefore a matter of the greatest importance to the grower, for it is necessary for him to know the causes responsible for consistent yield variation in his orchard in order that the proper steps may be taken to remedy them. Environmental causes for yield differences may be possible to correct by means of changes in orchard management practices. Inherent causes may be impossible to correct, requiring the removal of trees or top-working them to more productive strains.

Making the Distribution Chart.—Different methods may be used in making the distribution chart. The important matter is to visualize the distribution of the trees in the orchard according to whether they are low producers, medium producers, or good producers. This may be done by charting the orchard, with each tree represented by a small square, and coloring each square according to the four

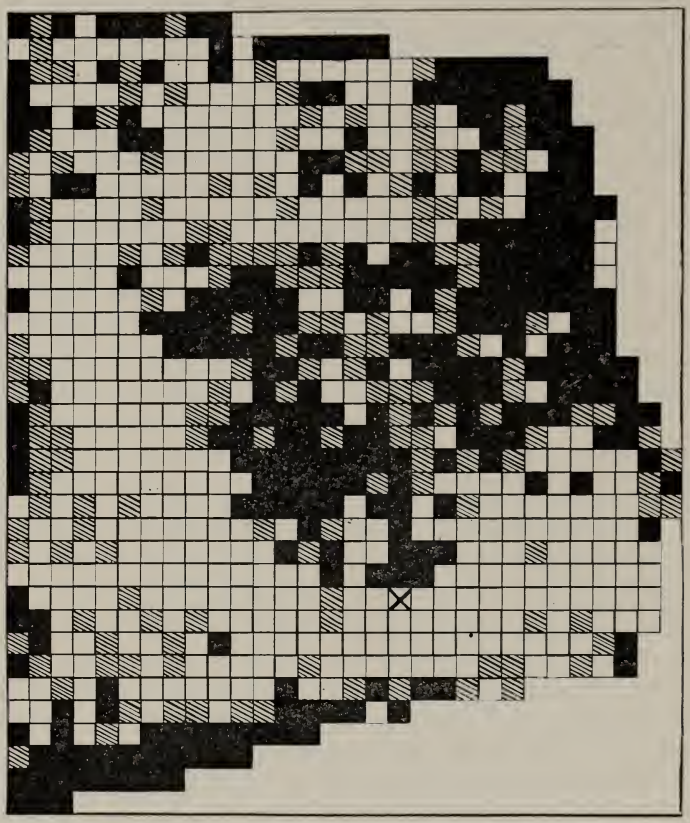


Fig. 7.—Distribution chart made up in solid colors. The black squares represent unprofitable trees (boarders); the cross lined squares, self supporting trees; and the white squares, profitable trees. Note the zonal groupings indicating environmental causes.

year average production record made by the tree it represents. (fig. 7.) This requires considerable work, however. The same results may be had where production estimates are recorded on the orchard chart, by inking in the pencil records in three contrasting colors, classes 1 and 2 in one color, class 3 in another, and classes 4 and 5 in still another. (fig. 8.) In case the latter system is used, significant distribution groupings may be established at the end of

the first year of record keeping by merely inking in the production records. Each year these groupings will become more clearly outlined as further records are inked in.

Environmental Factors.—Of the various environmental factors which may be reflected in tree yields, those related to soil conditions are by far the most important. Unfavorable soil moisture conditions in all probability constitute the most common environmental cause of poor yields. The marked variations in soil texture which occur

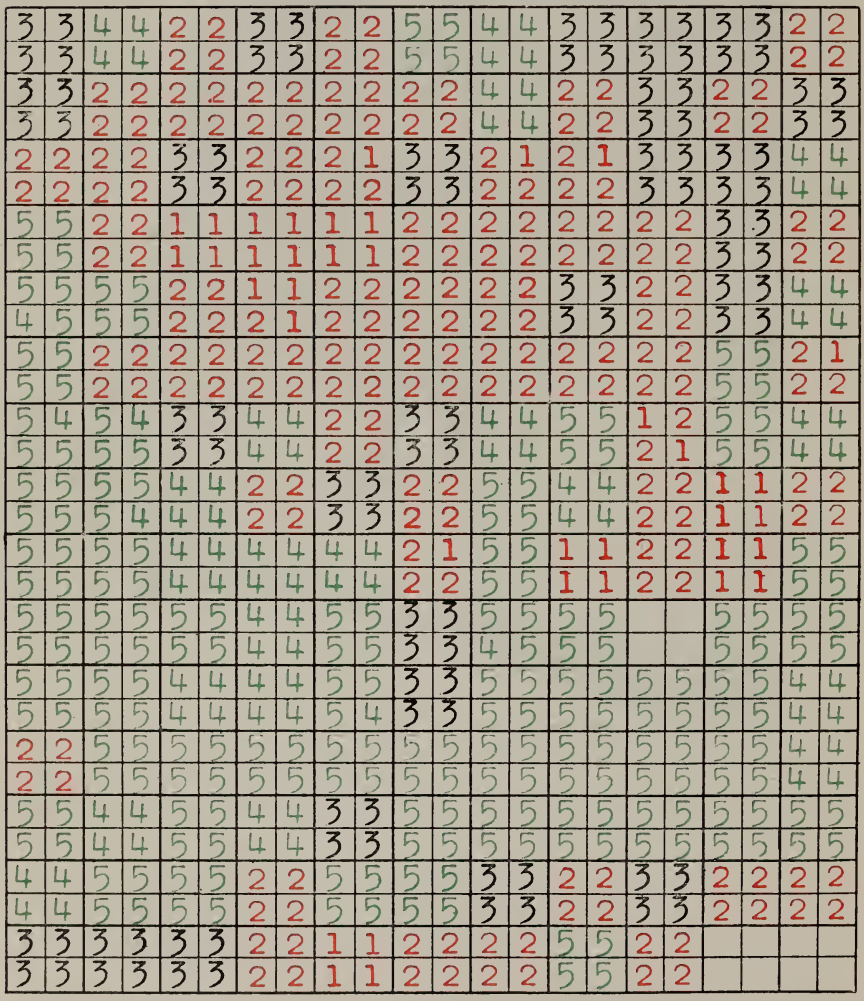


Fig. 8.—Portion of distribution chart and production record showing estimate records in different colors. Part of same orchard shown in figure 7. Numerals 1 and 2 represent unprofitable trees; 3, self-supporting trees; and numerals 4 and 5, profitable trees. This form of distribution chart is recommended.

within comparatively small areas are well known to citrus tree growers. The effects of such variations on soil moisture conditions, and especially the importance of adapting the irrigation practice to the soil requirements, however, have not been sufficiently appreciated. Distribution charts frequently show broad bands of low producing trees extending across either the upper or the lower ends of blocks of trees, and in some cases across both ends. The occurrence of such almost invariably reflects improper irrigation practice, the irrigation furrows generally being found to be too long for efficient penetration of the irrigation water. In the case of the heavier soil types, the trees at the lower ends of the furrows commonly do not receive enough water, which is strikingly visualized on the distribution chart in a band of low yielding trees. On the lighter soils the reverse may be true, the trees at the upper ends of the furrows receiving too much water and suffering both from the lack of soil aeration and from the leaching down below the root feeding area of the soluble nitrates. In some cases, both conditions are found, a band of low producing trees occurring at both the upper and the lower ends of the furrows. Improper irrigation practice may also show up in irregularly shaped areas, reflecting spotted soil conditions.

Variations in soil fertility are frequently responsible for poor yielding areas. Distribution charts have brought out strikingly certain low yielding areas which on further analysis have been found to coincide with elevations from which the top soil was removed at the time the land was levelled and prior to the planting of the trees. In a number of such cases, resurfacing these areas has resulted in a marked improvement in vigor and productivity on the part of the trees. Distribution charts rather frequently direct attention to areas where examination reveals the fact that the soil is much lighter in texture or shallower in depth than in the rest of the orchard, and although the irrigation practice may be adapted to the soil type, and soil moisture conditions may be satisfactory, the trees are prevailingly low in production. Under such conditions, increased fertilizer applications have usually caused marked improvement in yield.

In general, the first soil factor to examine is moisture. If moisture conditions are favorable, or after they have been made so, then the question of fertility should be analyzed. In the majority of cases, however, the two will be found rather intimately associated in their effects on tree yield. One of the most interesting examples illustrating the close relation of the two is the striking effect of windbreaks which the distribution chart usually shows.

Environmental factors which should not be overlooked are topographical conditions which cause frost "pockets" or "channels," and areas where pests or diseases are localized.

The means of modifying or overcoming these environmental factors are naturally suggested by the character of the factor or factors which on analysis are found to be responsible for yield variation.

Fig. 9.—Common type of uncongenial lemon bud-union. An inherent cause responsible for many unprofitable trees.

The important matter, however, is to analyse the areas which the distribution chart reveals, and on the basis of what is found, to apply measures calculated to increase tree yields.

Inherent Factors.—The principal inherent factors limiting yields are the character of the stock on which the tree is propagated and the inherent fruit-bearing capacity of the parent tree from which the bud-wood used in propagation was taken.

It is well known that there is much variation in the stocks on which citrus trees are propagated. A certain percentage of the seedlings prove to be unsatisfactory for various reasons, principally slow growth and unsatisfactory bud union (fig. 9). While many of these are discarded in the nursery, some are not detected and eventually are planted in the orchards. These trees rarely prove satisfactory in production. Many of them fail to grow properly and become undersized and unprofitable trees.

It is also well known that certain stocks, notably the trifoliate, usually exert a dwarfing effect on most varieties. While trees propagated on this stock may bear heavy crops, the small size of the trees usually renders them unprofitable.

At the present time the only practice which can be recommended is the pulling out of such trees and their replacement. Inarching, using seedlings of more desirable stocks, may eventually be found to be a successful method of stimulating trees of this character to satisfactory growth and production. At present, however, the use of this method for such purposes is purely experimental.

In cases where the stock is satisfactory and analysis fails to reveal an environmental factor responsible for low production, it may be concluded that the tree itself represents an inherently low producing strain, several of which are known to exist. The recommended treatment for such trees is top-working, using bud-wood taken from trees of known high yielding character. The advisability of top-working lemon trees, however, especially to orange varieties, is seriously questioned by many growers of long experience.

THE TREE HISTORY RECORD

As a means of having available at all times, accurate information as to the condition of each tree in the orchard, the keeping of an individual tree history record is invaluable. By means of such records the grower is enabled to control all factors of a disease or pest control nature before the injury from such has progressed to the point where decreased productivity results (fig. 10). Such records may also be used to record other data of importance such as the age of the trees, history with respect to top-working, disease treatment and pest control, all of which are helpful in correctly interpreting analyses of the type herein suggested.

Tree Inspection.—The data necessary for the keeping of an individual tree history record should be taken at least once a year and twice a year is recommended for the first year or two after the keeping of

such records is started. Each tree should receive a careful inspection, suitable notes being taken to show conditions which should receive immediate attention. These records should be summarized according to the character of the treatment necessary, and arrangements made to treat the trees at the proper period.

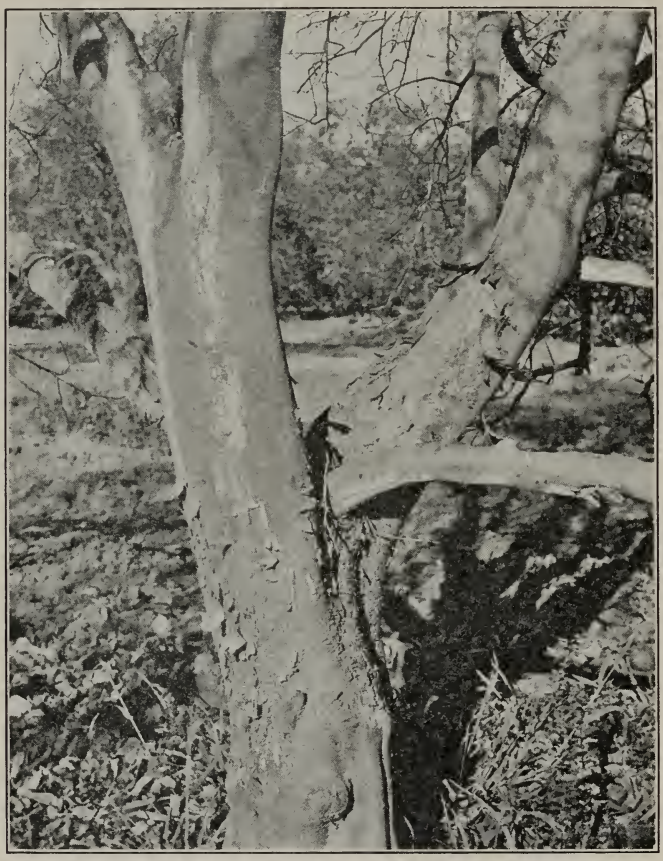


Fig. 10.—A severe case of orange scalybark of long standing. Semi-annual or annual tree inspection and the keeping of a tree history record would have indicated this condition while the disease was in the incipient stages and eradication comparatively simple.

The use of such records not only saves time in locating the trees requiring treatment, a most important item in itself, but also reminds the owner of the importance and necessity of individual tree care, as a means toward greater efficiency.

The Tree History Record Form.—The tendency for the grower starting a system of keeping tree history records is to take down much more information concerning the condition of each tree than

is necessary or desirable. The key-note to a satisfactory system of tree history record keeping is simplicity. It should be assumed that conditions of disease or pest injury noted will receive treatment, which renders it unnecessary to indicate either the stage or the severity of the condition. The treatment itself is the important matter; consequently it is not necessary even to distinguish between the different classes of diseases or conditions which require the same

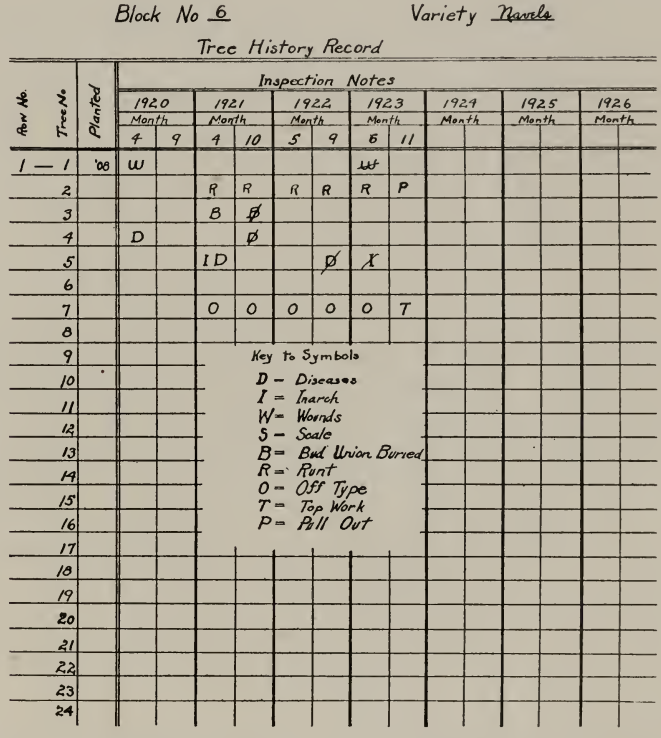


Fig. 11.—Recommended type of tree history record form.

or similar treatment. To illustrate: Brown rot gum disease, lemon shell-bark, gray mould gum disease, and scalybark, all require similar treatment and may therefore be grouped together under the same symbol; severe oil injury, foot rot, and gopher injury, present to the degree of partially or entirely girdling the tree, all require approximately the same treatment, inarching, and may conveniently be grouped under the same symbol. When inspection indicates that the condition has been overcome, this fact may be shown by the proper symbol with a line drawn through it.

The data needed on the tree history record are essentially the row number and tree number (tree identity and location), the date of planting (especially important for replants), and spaces for recording treatments required as indicated at either an annual or semi-annual inspection. A satisfactory form is that shown in figure 11.

CONCLUSION

By means of conducting the type of efficiency orchard analysis described in this circular, together with the keeping of simple tree history records, it is believed the citrus grower can furnish himself with extremely helpful information relative to ways and means for increasing his returns. The grower may determine for himself the relative efficiency of his orchard, and also the nature of the causes contributing thereto. He is then in a position to analyse these and to apply the proper remedial measures.

SUMMARY

Three sets of factors are operative in determining the production of citrus orchards: the cultural practices used, the inherent qualities of the trees, and the orchard environment.

Of these, the first two have received considerable attention. The third has been largely neglected. It is a factor of considerable importance and deserving of much more attention.

A means of visualizing the importance of this factor and its relation to the other two is described in this circular.

It consists of an orchard efficiency analysis which emphasizes the tree as the ultimate production unit of the citrus orchard and includes the following steps:

1. Establishing tree identities.
2. Keeping simple estimate production records.
3. Segregating the trees into classes according to yields.
4. Determining the efficiency of the orchard.
5. Determining the distribution of the trees in the orchard according to yields.
6. Ascertaining the causes of consistent yield variation as to whether environmental or inherent in character.
7. Analysing the causes determined and applying proper remedial measures.
8. Keeping a simple individual tree history record as an aid to increased tree efficiency.

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